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## (54) Method of transporting loads of shell-fish and apparatus suitable for use in such transportation.

(57) A method of transporting shell-fish at high load densities comprises immersing the shell-fish in sea water in a transportable container associated with a refrigeration system and with oxygenating means comprising an air pump (20 or 25) and air ducts (22) having discharge orifices through which air is discharged to form a multiplicity of ascending streams of fine bubbles distributed over the whole plan area of the container. The container is transported while operating the refrigeration system and maintaining sufficiently intensive oxygenation of the water to keep the shell-fish alive.

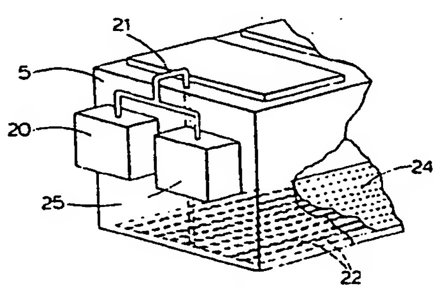


Fig.4

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Method of Transporting Loads of Shell-fish and Apparatus suitable for use in such Transportation

The method of this invention is useful in the transportation of loads of crabs and other shell-fish destined for marketing as such or for processing. The apparatus, while primarily intended for such transportation, can be used also for other purposes.

A conventional method of transporting loads of sea food from fishing ports to inland markets involves temporary storage of the catch in tanks at the fishing port and its subsequent packaging with ice in boxes which are then loaded into vehicles for overland transportation.

A serious disadvantage of this procedure, in addition to very high labour costs, is that a substantial proportion of the tonnage of food brought into port cannot be kept in prime condition for the period of time necessary for it to reach the inland markets where it would otherwise command a very good price. The period of time for which sea food will remain even in moderately good condition while boxed is very limited.

If edible matter liable to degrade on storage is simply stored on racks or in open receptacles in a refrigerated container problems arise from impeded cold air circulation over individual items unless they are stored in spaced relationship, which is of course very uneconomical and, for aquatic food animals, wholly impractical.

These and other problems involved in reducing the degradation of animal matter during storage are discussed for example in United Kingdom patent specification 1 037 296 and Australian patent specification 414 752. The latter specification proposes a method wherein the oxygen concentration in the atmosphere in the storage container is reduced by introduction of a purge gas, to a value of from ¼% to 5% by volume, before reducing the temperature in the container. Examples are given of the use of this method for storing fish maintained at about 35°F., and for storing shell-fish. It is stated that shell-fish were kept alive for two weeks in a storage container wherein the temperature was just above freezing point and the atmosphere had an oxygen concentration in the range 0.5 to 1% by volume and a humidity at about saturation point.

There is a particularly important need for an effective and economical method of transporting shell-fish in live condition. Crabs and other shell-fish will only realise their best market price if they are alive. However, notwithstanding the very important market demand, which has existed for a very long time, no economically viable method has so far been devised for meeting volume market demands for live shell-fish at places remote from their landing sites. The problem of sustaining life is illustrated by the fact that in coastal storage units in which lobsters are kept alive in running sea water it has been found necessary for keeping the catch alive in sea water at 55°F. to pump over 100 gallons of fresh sea water through the unit per hour per 100 lbs of lobsters. Obviously the problem associated with the transportation of large high density loads is even greater.

In our pending European Patent Application No 79300725.3 (publication No 0 005 353) there is disclosed a method of transporting fish or other aquatic farm material wherein the farm material is loaded with sufficient water to keep the material in wet condition, into a bulk load container having an associated refrigeration system and the container is transported while keeping the farm material in refrigerated wet condition by the refrigeration system. That method can be used for maintaining fish in good condition during transportion but the method as described does not enable shell-fish to be kept alive under high density storage conditions for any significant period of time.

The present invention provides a transportation method and apparatus whereby loads of shell-fish can be economically transported in live condition over appreciable distances, either for marketing as such or for processing.

According to the present invention there is provided a method of transporting a load of shell-fish for the food market, which method comprises the steps of:

- providing a transportable container which is capable of being loaded with water and is associated with refrigeration means for maintaining the contents of the container below ambient temperature and with gas supply means whereby oxygen or an oxygen-containing gas can be continuously introduced into the water in the container from an extraneous source during transportation of the container
- loading the shell-fish while alive, and sea water, into said container, the quantity of

water being sufficient to submerge the shell-fish, and

- transporting the container while utilising the refrigeration and gas supply means to maintain the temperature and oxygen content of the water at levels such as to keep at least the majority of the shell-fish alive until unloaded from the container.

By this method shell-fish can be kept alive in the container for several days with an appreciably higher storage density/mortality ratio then hitherto possible. Tests have shown that even spider crabs, which it has hitherto proved impossible economically to transport in live condition to inland markets, can by a method according to the invention be transported live in loads of several tons at a storage density of 2 lbs per gallon of sea water and with a mortality of less than 10% even over a period of 5 days, provided the temperature of the water is properly controlled and the oxygenation rate is sufficiently intense.

Because the shell-fish can be kept alive in the container for relatively long periods of time the container can remain at a quayside for loading at intervals of time with successive catches of shell-fish, and moved away only when it has a full load, so making the most efficient use of the transport service.

The attainment of the required results is dependent on the combination of refrigeration and oxygenation of the water and the maintenance of appropriate temperature and oxygen levels. Tests have shown that neither refrigeration nor oxygenation will suffice on its own. By keeping the water in chilled condition at a temperature as low as is tolerable to the stored species,

life can be prolonged, but it is not possible by that step to achieve cost effective results because either the maximum storage density permissible is too low or the mortality rate is unacceptably high. Circulation and filtration of the chilled water through the storage space may improve the results but not to a sufficient degree. Likewise oxygenation of the water has been found in itself to be incapable of solving the problem. But by combining refrigeration with intensive oxygenation throughout the water volume remarkable results are achieved.

The most suitable temperature of the water for a given species depends on the oxygenation rate and vice versa. The temperature range within which the water should be kept must depend in each case partly on the nature of the stored species and should, preferably be as low as possible within that range. Other things being equal, the lower the temperature of the water the lower is the oxygenation rate necessary for keeping the mortality below a certain level for a given length of time.

The temperature of the sea water during containment of the shell-fish is preferably maintained between 40°F. and 55°F. and most preferably between 45° and 55°F. This is appreciably below the temperature of the water environment of the crustaceans during the summer fishing season. It is important that they are not subjected to abrupt and marked temperature changes and at least when caught under summer temperature conditions the animals should be placed in sea water at a temperature in the region of that from which they were extracted and the

temperature then gradually lowered to the desired storage temperature within the above range. This temperature adjustment can be made in the transportation container itself or in separate tanks from which the animals are then transferred to the container.

The sea water should be intensively and continuously oxygenated throughout its volume. The oxygenation is preferably maintained by forcing air into the water from discharge orifices distributed over the bottom area of the container so that the air forms a multiplicity of ascending streams of fine bubbles. Preferably the air supply is cooled directly or indirectly by the refrigeration system before the air enters the water.

The oxygen content of the sea water measured at the surface zone of the water in the container should generally be maintained above 60% of the saturation value at the prevailing water temperature and it is preferable for this oxygen content to be kept above 70%. The oxygenation rate which is necessary to sustain this level depends on the storage density of the shell-fish and on the temperature.

Preferably the method is carried out for transporting a load of shell-fish at a storage density in the container of at least 1 pound and most preferably at least 1.5 pounds weight of shell-fish per gallon of water. When transporting large loads at that density the potential economic benefits of the invention are realised to a favourable extent. Generally speaking, the carrying of loads larger than 1 ton of crabs or larger than 3 hundredweight

of lobsters is desirable for achieving the highest cost effectiveness of the method. Loads up to 10 tons of crabs can be economically carried by a method according to the invention. Tests have shown that 1200 pounds of live spider crabs stored at a density of 2 pounds per gallon of water can be kept alive with very low mortality, for up to five days in sea water at 50°F by injecting 100 $ft^3$ of cooled air into the water per hour.

The water can be circulated through the container during the storage period and filtration means can be employed for removing organic material. This re-circulation and filtration will be desirable if the shell-fish are not held for a short period in temporary storage tanks or pools to allow stomach evacuation prior to loading of the shell-fish into the transportation container.

In certain embodiments of the invention the shell-fish load is composed of relatively small quantities held separated in removable receptacles which are of openwork construction so that the shell-fish in the receptacles are exposed to the water in which the receptacles are immersed. Preferably the individual quantities are not more than 30 to 45 pounds in weight. The receptacles can for example be in the form of open-work boxes or baskets. These may be made of plastics material. The receptacles are preferably formed so that they inter-engage when stacked.

In preferred embodiments of the invention the shell-fish are free within the water i.e. they are confined only by the walls of the container defining the load space. Such methods have the advantage that the period of time between landing of the shell-fish and

their entry into sea water in the container is shorter, because the shell-fish are not first loaded into boxes or baskets. It may be advantageous however, depending on the size of the container, for the load space in the container to be sub-divided by partitions in order to ensure that a satisfactory distribution of the load over the plan area of the container is maintained.

The refrigeration means preferably comprises passageways which convey fluid refrigerant and are located adjacent and in heat-conducting relationship to a heat-conducting skin defining the liquid-holding space. By this means very uniform cooling of the liquid throughout its volume is promoted. Such unfirom cooling in conjunction with intensive oxygenation is highly conducive to the reduction of mortality to very low levels even with high density storage over some days duration. The said passageways can form part of a refrigeration system of the compression/expansion type or be coupled to a source of liquefied gas.

The container can be of any required form suitable for its intended use and mode of transportation. It is particularly advantageous for the container to form an integral load-carrying body of a vehicle or a vehicle trailer e.g. a semi-trailer, or to form a demountable vehicle load container of the roll-on/roll-off type.

Particularly for use in transporting live shell-fish held in stacked boxes within the container as hereinbefore described, it is very suitable for the container to have one or more top hatches and for its height and the level to which it is filled with water to be such that a person can stand in the water in the container and unload receptacles containing shell-

fish, via said hatch(es).

The container used in a method according to the invention can form a tipping body of a load-carrying vehicle and have a sealable tail end discharge opening.

The invention includes apparatus suitable for use in transporting a bulk load of water and immersed shell-fish, which apparatus comprises a bulk load container which has heat-insulated walls and is associated with refrigeration means for maintaining the contents of the container below ambient temperature and with gas supply means whereby oxygen or an oxygen-containing gas can be continuously introduced into the liquid in the container from an extraneous source during transportation of the container.

Such apparatus can incorporate any of the optional features, e.g. water-circulation means, required for making use of any of the optional features of the method hereinbefore described.

Apparatus according to the invention can be used not only in carrying out a transportation method according to the invention as hereinbefore defined, but also for other purposes. For example the apparatus can be used without operating the oxygenating system for carrying fish which must be kept in good edible condition but need not be kept alive. Said apparatus can also be used, with or without operating the oxygenation system, for carrying other kind of materials, e.g. foodstuffs of various kinds.

Certain embodiments of the invention will now be described by way of example with reference to the accompanying diagrammatic drawings in which:

Fig.1 is a general view of a container forming part of an apparatus according to the invention;

Fig. 2 is a fragmentary sectional view of part of a side wall of the container;

Fig.3 is a fragmentary sectional view of part of the bottom wall of the container; and

Fig.4 shows the oxygenation system associated with the container.

The illustrated container is of elongate rectanguloid form, having opposed side walls 1 and 2, a bottom wall 3 (Fig.3) end walls 4,5 and a top wall 6. The bottom, side and end walls together define a water-tight load-carrying space. The top wall 6 is provided with hatches fitted with removable sealing covers 7.

The container is constructed almost entirely from sheet aluminium alloy of a specification within British Standard Specification 1470. Each of the top, bottom, side and end walls is double-skinned and rigidity is imparted to the structure by a system of between-skin ribs such as 8,9 which extend over the height and width of the container at intervals along its length, and ribs such as 10 which extend along the horizontal corner edges of the body. The various ribs are hollow and formed by strips of aluminium, bent to channel section and welded to the skins.

The container is provided with five cooling coils located one on the bottom wall of the container and two against each of its side walls. The two cooling coils at each side are disposed one above the other. Fig 1 shows in broken lines the path of one of the cooling coils designated 11, at the nearer side wall of the container.

The walls of the container comprise inner and outer aluminium skins 12,13 which are welded to the ribs 8,9 and 10. Thermally insulating material 14 (Fig.2) is disposed between the inner and outer skins of each wall so as substantially to fill the inner-skins space and layers of wood 15,16 are disposed between the outer skin and the said ribs. In Figs.2 and 3 the thermal insulation 14 has been shown partly broken away to expose the vertical ribs 8,9. A very suitable thermally insulating material 14 is polyurethane foam.

Quantities of such insulating material are also disposed within the hollow ribs 8.

Fig. 2 shows lengths of tubing 17 which make up part of the upper cooling coil of the side wall 2. The tubing is formed of HE30 WP TB aluminium alloy (British Standard Specification 1470). The tubing is of square or rectangular cross-section providing a flat face which is located in contact with the inner skin 12. The inner face of the side wall is profiled to provide spaced horizontal channels such as 18 in which the tubing is located. The tubing is clamped to the inner skin by clamping strips (not shown) disposed at internals along the courses of the tubing. Elastically deformable material is disposed between each clamping strip and the tubing so that the tubing is firmly clamped against the inner skin but small relative movements between the tubing and the inner skin can take place in consequence of differential thermal expansion and contraction.

The end and top walls 4, 5 and 6 of the container are of similar double-skin heat-insulated construction but are without cooling coils.

The cooling coils are connected with a refrigeration plant (not shown) of a type known per se, which plant may for example be as described and illustrated in published European specification No 0 005 353 hereinbefore referred to.

Instead of using a refrigeration system of the compression and expansion type, the cooling coils may be coupled with one or more reservoirs of liquefied gas, e.g. liquefied nitrogen, from which coolant is released and caused to flow in vaporised condition through the coils.

The refrigeration plant or coolant reservoir may be connected to the load-carrying container, e.g. to a container-supporting sub-frame 19, so that the container and refrigeration plant or coolant reservoir can be handled as a unit. Alternatively such plant or reservoir may be mounted separately from the container, for example on a vehicle for carrying the container.

The illustrated container is also equipped with means for oxygenating water in the load-carrying body. This system comprises a motor-driven air pump or compressor 20 (Fig.4) mounted externally of the container at one end thereof. The outlet of this power source is connected to a duct 21 which passes through the top wall of the container to its interior where it is connected to ducts 22 (Figs. 3 and 4) which extend along the bottom of the container. As shown in Fig.3, these ducts, like tubing 23 forming part of the bottom cooling coil of the container, are disposed in channels defined by the inner skin 12 of the bottom wall. Along each of the ducts 22 there is a series of orifices such as 23 for the discharge of air along the whole length of the container. Above the inner skin 12 of the bottom wall there is perforated plating 24 acting as a diffuser for promoting good distribution of air over the load-carrying area.

The compressor 20 may be driven by a small internal combustion engine and an electrically driven compressor 25 may be provided for stand-by use, powered e.g. by a power pack on the vehicle or by an extraneous power source.

An air vent 26 (Fig.1) is provided at the top of the container to avoid build up of air pressure over

the load in the container.

The interior of the container can be fitted with partitions, e.g.like partitions 27 shown in broken line in Fig.1, which divide the interior of the container over part of its height into compartments. This can be useful for distinguishing different parts of a load and (if the animals are loose) for keeping the load well distributed through the load space.

If the container is used for transporting shell-fish held in boxes stacked within the container, the boxes can be unloaded via the top hatches. For this purpose the person responsible for unloading the boxes can step into the container via one of the hatches and if suitable waterproofs are worn there is no need for the container to be emptied of water.

The container can be lifted onto a transportation vehicle by means of a crane or other mechanical handling gear. As an alternative the container may be fitted with retractable legs such as 28 shown in broken line in Fig.1 and otherwise designed for direct loading onto a vehicle which is backed beneath the container.

The container can be provided with a water inlet such as 29 and a water outlet such as 30 (Fig.1) via which water can be circulated through the tank via a filter, for reasons hereinbefore described.

The container can be provided with coupling points by which it can be coupled to a mains source of cold and/or to a mains power supply. This can be useful e.g. for enabling a load to be kept refrigerated and aerated by using energy sources available on a ship in the event of the container being carried by sea or river.

In an alternative embodiment of the invention (not shown) the container serves as the integral load-carrying body of a vehicle equipped with tipping mechanism whereby the container can be tipped for discharging contents via a tailgate. Such a vehicle may be as illustrated in Fig.1 of published European specification No 0 005 353 but with the addition of an oxygenation system for oxygenating the water in the container.

The following in an example of a method according to the invention employed for transporting live spider crabs. The conditions applied in these examples can also be employed for transporting live brown crabs and lobsters although it will generally not be required to transport such large loads of lobsters and therefore for that purpose smaller capacity containers can be used.

Example 1

Apparatus as described with reference to the accompanying drawings incorporating a container having a total interior volume of 32 cubic yards and without interior partition walls 27 was used for transporting 3 tons of spider crabs which had been held for a few days in the sea in nets or rafts. The 3 tons load of crabs was divided into quantities each weighing between 30 and 45 lbs and each quantity was placed in a plastics basket large enough to hold that amount. The baskets were loaded into the container to form stacks distributed over its bottom area. High saline sea water (specific gravity above 1.023) at approximately the temperature of the water inhabited by the crabs prior to transfer to the baskets was then run into the container until the water level reached approximately 1 foot above the stacks of

baskets. The crabs were in prime live condition when placed in the baskets and the filling of the baskets and their loading into the container was completed sufficiently quickly to ensure that the crabs did not become moribund.

The refrigeration plant and aeration system were put into operation immediately after completion of loading of the container. The refrigeration system was controlled so as slowly to reduce the temperature of the water to approximately 50°F. and that temperature was maintained to within 5°F. for as long as the crabs remained in the container. The aeration system was operated from the beginning to pump air into the water at a rate of approximately 0.22 NTP cubic feet of air per minute per cubic foot of water. By this means the oxygen concentration of the whole volume of water was maintained at a high level. The oxygen concentration measured at the surface of the water was at least 80% of the saturation value. There was no circulation of the sea water out of and back into the container. Tests were made at intervals of time and it was found that even after 3 days, during which the container was transported by road, the mortality was only 12%. This was a far better result than can be achieved by previously known storage methods, even storage in running sea water in conventional shore tanks.

Example 2

Apparatus as described with reference to the accompanying drawings was employed, the container having internal partition walls 27. The container was first partly filled with high saline sea water (about 5600 gallons) and the refrigeration and aeration

systems were set in operation to maintain the water at approximately 50$^{\circ}$F. and to keep the water intensively oxygenated ( more than 70% of the saturation level at the surface). About 5 tons of spider crabs were loaded directly from the sea (where they were confined by nets) into the container. The crabs were not first put into baskets or other receptacles. But the load was subtantially uniformly distributed to the different compartments in the container. It was found that after 5 days, during which the container was transported by a road vehicle, more than 90% of the crabs were still in prime live condition.If circumstances require the removal of organic wastes during the storage in the container a water circulation system can be employed by which water is continuously withdrawn from an outlet 30 (Fig.1) and pumped back into the container via inlet 29 after filtration, e.g. by a foam rubber filter held in an auxiliary tank.

In carrying out the present invention it is possible to use artificial sea water but in most circumstances it is important for economic reasons to use natural sea water.

Claims:

1. A method of transporting a load of shell-fish for the food market, which method comprises the steps of:

- providing a transportable container which is capable of being loaded with water and is associated with refrigeration means for maintaining the contents of the container below ambient temperatures and with gas supply means whereby oxygen or an oxygen-containing gas can be continuously introduced into the water in the container from an extraneous source during transportation of the container
- loading the shell-fish while alive, and sea water, into said container, the quantity of water being sufficient to submerge the shell-fish, and
- transporting the container while utilising the refrigeration and gas supply means to maintain the temperature and cxygen content of the water at levels such as to keep at least the majority of the shell-fish alive until unloaded from the container.

2. A method according to claim 1, wherein the oxygen content of the water measured at the surface zone of the water in the container is maintained at above 60% of the saturation value at the prevailing water temperature.

3. A method according to claim 2, wherein said oxygen content is maintained above 70%.

4. A method according to any preceding claim, wherein air is forced into the water in the container from discharge orifices distributed over the bottom area of the container so that the air forms a multiplicity of ascending streams of fine bubbles.

5. A method according to any preceding claim, wherein the gas is supplied along passageways which are directly or indirectly cooled by the refrigeration means.

6. A method according to any preceding claim, wherein the temperature of the sea water in the container is maintained between $40^{\circ}$ and $55^{\circ}$F.

7. A method according to any preceding claim, wherein the load of shell-fish in the container is at a storage density of at least 1 pound weight per gallon of water.

8. A method according to any preceding claim, wherein the load in the container comprises at least 1 ton of crabs or at least 3 hundredweight of lobsters.

9. A method according to any preceding claim, wherein the load of shell-fish is composed of quantities held separated in removable receptacles which however leave each quantity exposed to the water in which the receptacles are immersed.

10. A method according to claim 9, wherein said receptacles containing said quantities of shell-fish are distributed in stacks in the container and air is continuously discharged into the water from beneath each stack.

11. A method according to any of claims 1 to 8, wherein the load space in the container is sub-divided by partitions into compartments and the shell-fish are free in those compartments.

12. A method according to any preceding claim, wherein the refrigeration means comprises passageways which convey fluid refrigerant and are located adjacent and in heat-conducting relationship to a heat-conducting skin exposed to the interior of the container.

13. A method according to claim 12, wherein said passageways are provided along opposed side walls and the bottom of the container.

14. A method according to any preceding claim, wherein said container forms the load-carrying body of a vehicle or vehicle trailer.

15. A method according to any of claims 1 to 13, wherein said container is constructed as a demountable vehicle load container of the roll-on/roll-off type.

16. A method according to any preceding claim, wherein the container has one or more top hatches and its height and the level to which it is filled with water are such that a person can stand in the water in the container and unload receptacles containing shell-fish, via said hatch(es).

17. Apparatus suitable for use in transporting a load of water and immersed shell-fish, characterised in that the container has heat-insulated walls and is associated with refrigeration means for maintaining the contents of the container below ambient temperature and with gas supply means whereby oxygen or an oxygen-containing gas can be continuously introduced into the liquid in the container from an extraneous source during transportation of the container.

18. Apparatus according to claim 14, wherein said gas supply means comprises gas discharge orifices distributed over the bottom area of the container.

19. Apparatus according to claim 18, wherein gas supply passages leading to said orifice are arranged so as to be cooled by said refrigeration means.

20. Apparatus according to claim 18 or 19, wherein gas-diffusing means is provided at the bottom of the container, above said gas discharge orifices.

21. Apparatus according to any of claims 17 to 20, wherein there is means for circulating water through the container via a filtration means.

22. Apparatus according to any of claims 17 to 21, wherein passageways for conveying fluid refrigerant are provided adjacent and in heat-conducting relationship to a heat-conducting skin exposed to the interior of the container.

23. Apparatus according to claim 22, wherein said passageways are provided along opposed side walls and the bottom of the container.

24. Apparatus according to any of claims 17 to 23, and forming the load-carrying body of a vehicle or vehicle trailer.

25. Apparatus according to any of claims 17 to 24, and constructed as a demountable vehicle load-container of the roll-on/roll-off type.

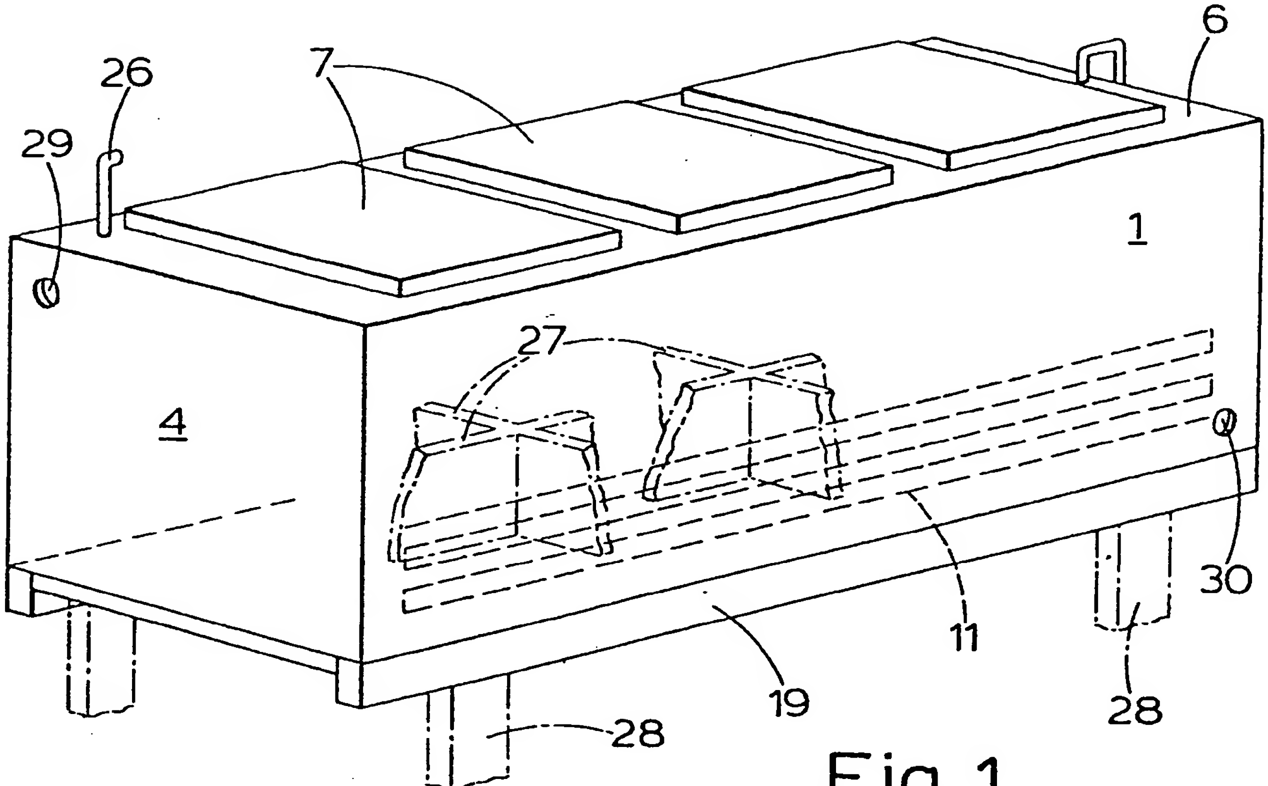


Fig.1

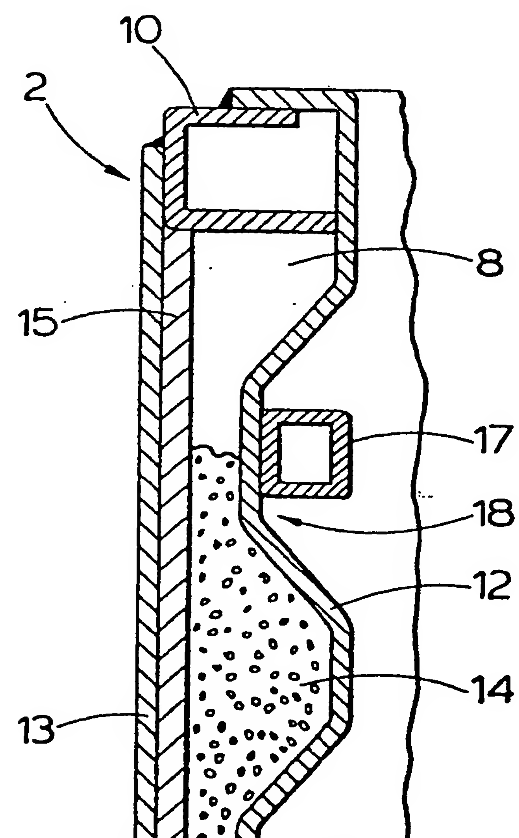


Fig.2

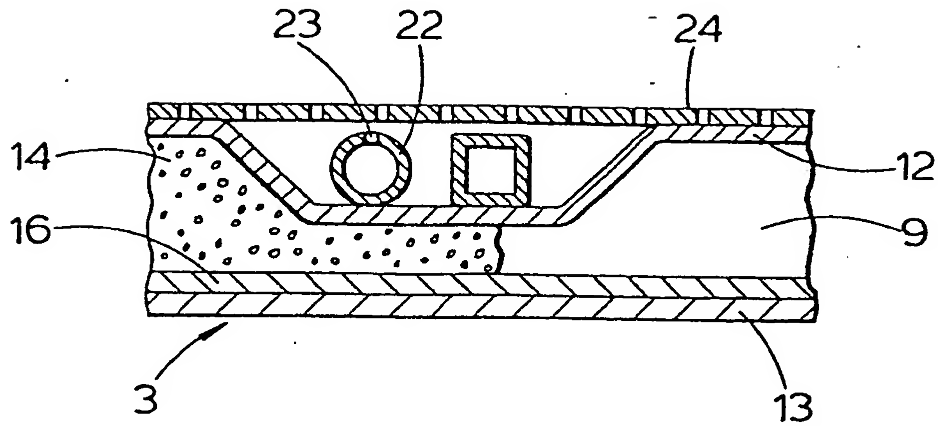


Fig.3

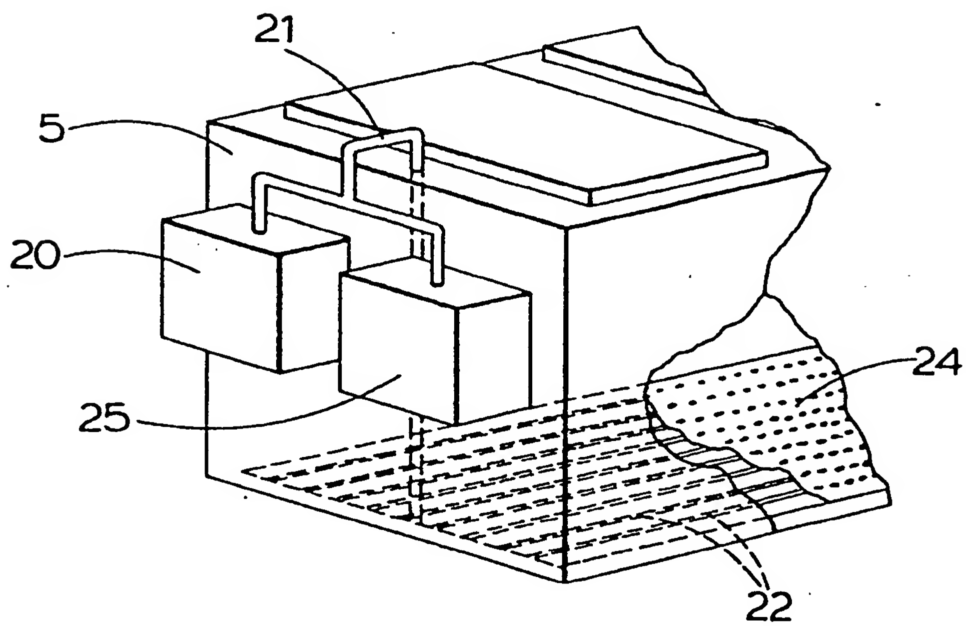


Fig.4

0023145

European Patent Office

# EUROPEAN SEARCH REPORT

Application number

EP 80 30 2448.8

| Category | Citation of document with indication, where appropriate, of relevant passages | Relevant to claim |
| --- | --- | --- |
| | DE - U - 1 784 001 (QUAST et al.) * entirely * | 1,4,9, 10, 14-16, 18 |
| | GB - A - 1 488 311 (DOUTRELEPONT) * entirely * | 1,2,14, 17,24 |
| | US - A - 1 891 779 (ROBBINS) * fig. 1 to 4 * | 1,14-16 |
| | FR - A - 2 081 076 (ATELIERS ET CHANTIERS DE LA MANCHE) * fig. 1 * | 1,12,21 |
| | US - A - 2 286 146 (LOOK) * fig. 1, 2 * | 1,21 |
| | DE - C - 534 755 (WIESSNER) * entirely * | 1,4 |
| | US - A - 3 306 256 (LEWIS) * column 2, lines 67 to 69 * | 6 |
| A | US - A - 3 727 579 (LEE) | |

CLASSIFICATION OF THE APPLICATION (Int. Cl.3)

A 01 K 63/02
B 60 P 3/20

TECHNICAL FIELDS SEARCHED (Int.Cl.3)

A 01 K 63/00
B 60 P 3/00

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
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L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
| --- | --- | --- |
| Berlin | 17-10-1980 | LUDWIG |

EPO Form 1503.1 06.78